#945

UNITED STATES DEPARTMENT OF AGRICULTURE

FOREST SERVICE

REGION 10

SKOWL ARM

DDT PILOT PROJECT

JUNE 1963

22; 33, 37; — ; —

10,000
1/4 lb/acre
2500 lb DDT

FOREWORD

The operational and biological phases of the Skowl Arm DDT Pilot Project were conducted under the overall supervision of Raymond W. Karr, Forest Staff Officer in the South Tongass Supervisor's Office.

This report is an evaluation of the operational and biological phases of the pilot study and was co-authored by Merlin Pontious, Project Staff Officer in the South Tongass Supervisor's Office; David Crosby, head of the Regional Office Section of Forest Pest Control; and Bruce Roettgering, Project Leader of Forest Insect Detection Surveys in the Regional Office

Separate reports are being issued by the Alaska Department of Fish and Game covering wildlife studies and the Bureau of Commercial Fisheries of the U. S. Fish and Wildlife Service covering the effects of DDT on fish and associated aquatic fauna.

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PREFACE

The economic development of Alaska in recent years has clearly demonstrated the need for protecting the forests of southeast Alaska from the ravages of destructive forest insects. Where once little heed was given to dead and dying trees, we must now endeavor to keep timber losses resulting from insect activity to economically acceptable levels to insure dependable supplies of raw material for the new pulp mills now operating in Ketchikan and Sitka, as well as to meet increasing demands for spruce and cedar lumber.

The island complex of southeast Alaska, consisting of rugged mountains and numerous bays and inlets, poses many new problems for large scale insect spray projects. In this country, highways are almost non-existent and nearly all transportation is by water or air. Airports are few and far between and, under present conditions, it would not be practical to spray all the forests of the Region from existing airports.

Since the advent of DDT during World War II, the chlorinated hydrocarbon and organic phosphate insecticides have largely replaced the older type materials, such as lead arsenate, rotenone, and pyrethrin. Concomitant with the development of concentrated DDT sprays, requiring only one pound of DDT in one gallon of oil spread over one acre of woodland, was the use of surplus war planes for applying this new low volume spray. This combination of surplus planes, procurable at very low costs, and the low application rate of one gallon per acre resulted in protection costs of approximately $1 per acre. In the period 1945 to 1955 several million acres of forest lands were sprayed with DDT throughout the lower 48 states.

Initial work in Pennsylvania proved that 5 pounds of DDT per acre was very damaging, not only to insects but to many other forms of wildlife. Subsequent work showed that 1 pound of DDT per acre could control important defoliating insects while causing little harm to birds and important game fish when carefully applied. The Canadians, working in New Brunswick and British Columbia, soon discovered, however, that DDT at dosage levels of 1/2 pound or more per acre was extremely damaging to various species of salmon. Experimental work conducted in British Columbia indicated that 1/4 pound of DDT in 1 gallon of oil per acre would give reasonable control of the black-headed budworm without causing any appreciable harm to fish and wildlife.

In June of 1963, the U. S. Forest Service, in cooperation with the U. S. Fish and Wildlife Service and the Alaska Department of Fish and Game, conducted a 10,300 acre pilot project. The purpose was to obtain answers to the following five questions:

1. Is it feasible to conduct a water-based aerial spraying project?

2. What are the costs and equipment needs of a water-based project?

3. What effect does DDT applied at the rate of 1/4 pound per acre have on the black-headed budworm as well as the hemlock sawfly?

4. What effect does DDT applied at the rate of 1/4 pound per acre have on fish and other aquatic life?

5. What effect does DDT applied at the rate of 1/4 pound per acre have on birds and mammals.

This report will present the experience gained from this project relating to the first three questions. Separate reports by the U. S. Fish and Wildlife Service and the Alaska Department of Fish and Game will cover the experience gained from this project relating to the last two questions.

The U. S. Forest Service had no experience in spraying for forest insect control under southeast Alaskan conditions and therefore found it necessary to appeal to other agencies for assistance. Acknowledgment is hereby made to the following agencies for services received:

1. Region 6, U. S. Forest Service, for the services of Benton Howard in overall advice and technical assistance, and of John Childers as Project Flight Officer.

2. Region 9, U. S. Forest Service, for assistance in procuring samples of DDT for analysis.

3. U. S. Forest Service Insect Laboratory, Beltsville, Maryland, for technical assistance.

4. Agricultural Research Service, U. S. Department of Agriculture, Yakima, Washington, for analyses of spray materials.

5. Geological Survey, U. S. Department of the Interior, for installing and maintaining recording water-level gauges and for collecting associated stream flow data.

6. Weather Bureau, U. S. Department of Commerce, for weather information.

7. Coast Guard, U. S. Department of Treasury, for assistance in drafting search and rescue plans.

SUMMARY

1. Sufficient experience was gained to prove the operational feasibility of spraying the forests of southeast Alaska from a floating base using both the amphibious PBY plane and a Hiller 12E helicopter.

2. A projection of cost data obtained on this project indicates both spray craft capable of spraying 10,000 acres at a per acre cost of $1 for application.

3. Spray coverage obtained with the helicopter was superior to that of the PBY.

4. Release of blocks for spraying was based upon operational preparedness rather than insect development because of inadequate black-headed budworm populations.

5. No conclusions could be made concerning the effects of 1/4 pound of DDT on the black-headed budworm because of inadequate budworm populations. All studies to determine the effectiveness of such treatment were abandoned after efforts to establish budworm populations in the spray and check areas failed.

INTRODUCTION

Southeast Alaska has long been noted for its mineral wealth and its "silver hordes" of salmon, but the economic value of the forests was largely ignored until two large pulp mills were established in the Region, one at Ketchikan in 1954 and one at Sitka in 1959. Since these pulp mills require a dependable source of timber, forest management practices have become imperative. Between 1948 and 1955, an epidemic of the black-headed budworm, Acleris variana Fern., working alone or in conjunction with the hemlock sawfly, Neodiprion tsugae (Midd.), occurred in southeast Alaska. Stands of western hemlock, Tsuga heterophylla (Rafn.) Sarg., suffered extensive damage with an estimated loss of 268 million board feet of timber over 100,000 acres. During 1959 and 1960, routine insect surveys conducted by the U. S. Forest Service showed signs of increased activity on the part of the black-headed budworm and the hemlock sawfly, particularly the former.

The forested portions of southeast Alaska are a complex of generally mountainous islands and a mainland strip with many bays and inlets quite unlike any areas previously sprayed from the air for forest insect control. It was evident that new techniques would be needed for spraying the forests in this area. The timber losses resulting from the 1948-1955 budworm outbreak plus the possibility of recurring damage from a new outbreak led to a request from Region 10 to Region 6 for technical assistance in planning forest insect control measures. Benton Howard, in charge of insect and disease control for Region 6, was detailed to Region 10 in 1960 to make a detailed study of the problems to be expected in conducting an insect control program in southeast Alaska. His report[1/] served as a useful guide in planning the operational phase of the Skowl Arm Project.

Chemical control of forest insects must be both economical and effective. Since World War II, DDT and aerial spraying techniques have developed to the point where control of defoliating insects, such as the spruce budworm and the gypsy moth, has become a

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1/ Special report entitled "Black-headed budworm and hemlock sawfly control plan," prepared by Benton Howard, June 1960 for Region 10, U. S. Forest Service, U.S.D.A. On file in the Regional Forester's Office, Juneau, Alaska

relatively simple matter. The low over-all cost of $1 and even less per acre, including application costs, and its effectiveness against many insects caused DDT to become the almost universal insecticide for forest spraying. However, while the one pound per acre rate carefully applied could be tolerated by wildlife and most game fish, it has been clearly demonstrated in both eastern and western Canada that dosage rates of one pound and even 1/2 pound per acre are highly destructive to the several species of commercial salmon. The "pesticide problem" has assumed such proportions of late that a high priority was given by the Forest Service to finding a DDT dosage rate that would not cause significant harm to the salmon of Alaska and yet provide satisfactory control of the black-headed budworm. With the above considerations in mind, it was decided that a dosage rate of 1/4 pound of DDT in one gallon of oil per acre would be used in a pilot project to determine primarily the effects of 1/4 pound DDT on salmon and associated aquatic fauna.

The development of water-based operational techniques for use in future aerial insect control projects was the second major objective of the Skowl Arm Project. The PBY amphibian plane with a capacity of 1,500 gallons was a logical choice for a big spray plane. The helicopter was chosen because it could operate from a raft or floating base that could be towed close to the spray area and because of its generally recognized superior spray coverage. In addition, the use of the PBY and the helicopter made it possible to compare operational costs of these two differenct aircraft types.

Obviously it is not possible to spray a forest insect without considering the side effects of such treatment upon fish and wildlife and associated multiple use values. Consequently, from the initial planning stages of the Skowl Arm DDT Pilot Project there has been complete cooperation between the units of the U. S. Forest Service of the Department of Agriculture, the Bureau of Commercial Fisheries and the Bureau of Sports Fisheries and Wildlife of the Fish and Wildlife Service, U. S. Department of the Interior, and the Alaska Department of Fish and Game. Representatives of these cooperating agencies assembled four times before the actual spraying took place to coordinate work plans. These interagency meetings, started in 1960, have continued through post-spray conferences. All agencies have been kept fully informed of what the other agencies were doing. Significantly, tentative plans to spray in nearby West Arm of Cholmondeley Sound were dropped by the Forest Service when the Alaska Department of Fish and Game objected because of fish studied being conducted in the area.

Figure 1. PBY spraying in Cabin Creek, Prince of Wales Island.

Figure 2. Hiller 12E helicopter spraying in Dog Salmon Creek, Prince of Wales Island.

ORGANIZATION AND RESPONSIBILITIES

The project area was located on the Kasaan District of the South Tongass National Forest in the Skowl Arm portion of Prince of Wales Island as shown in figure 3.

The operational phase of the project was the responsibility of the South Tongass National Forest whose Assistant Forest Supervisor was designated Project Director. The biological phases of the project were handled by the Pest Control section within the branch of State and Private Forestry in the Regional Office at Juneau.

The organizational structure and functional responsibilities are shown in figure 4.

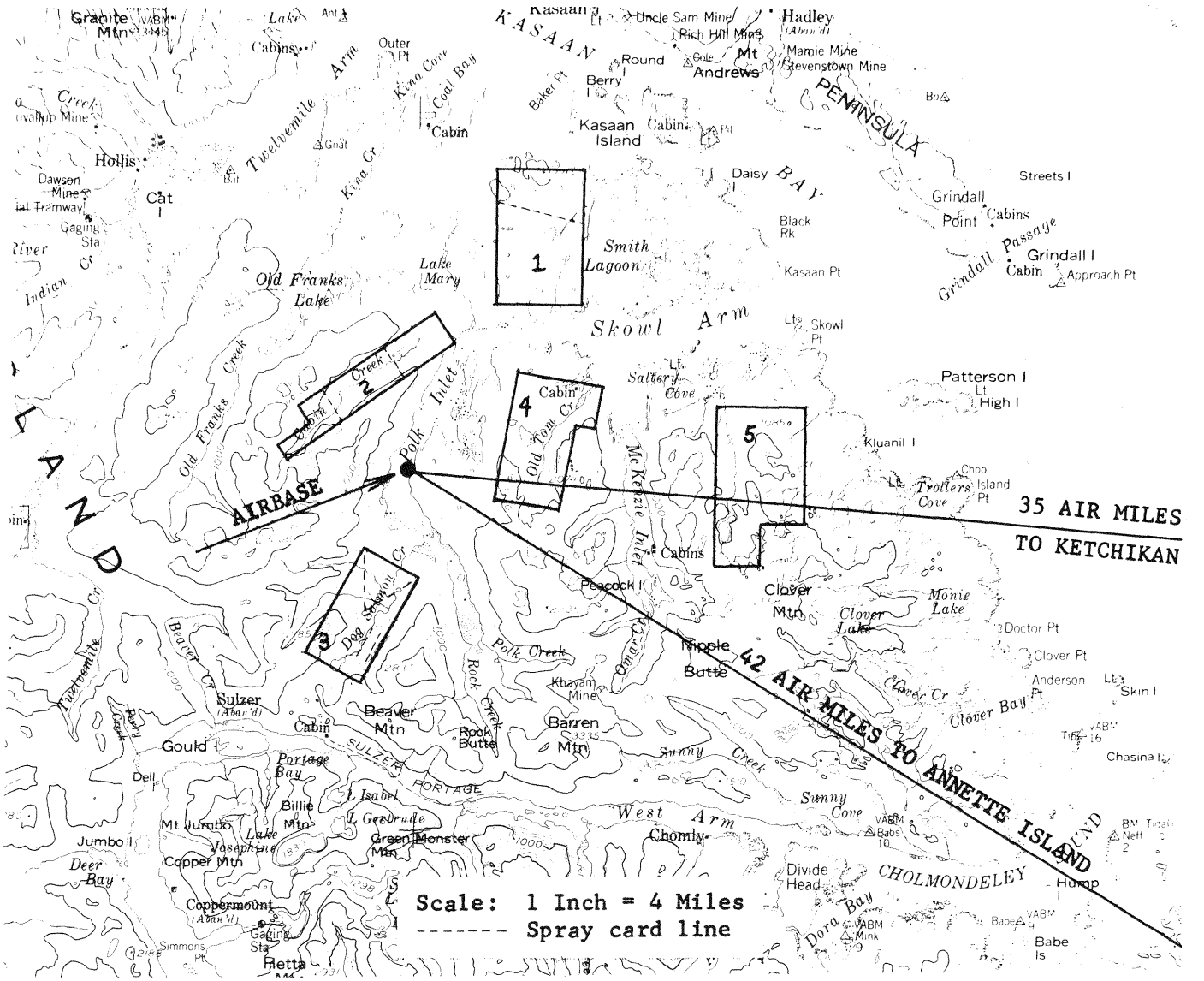
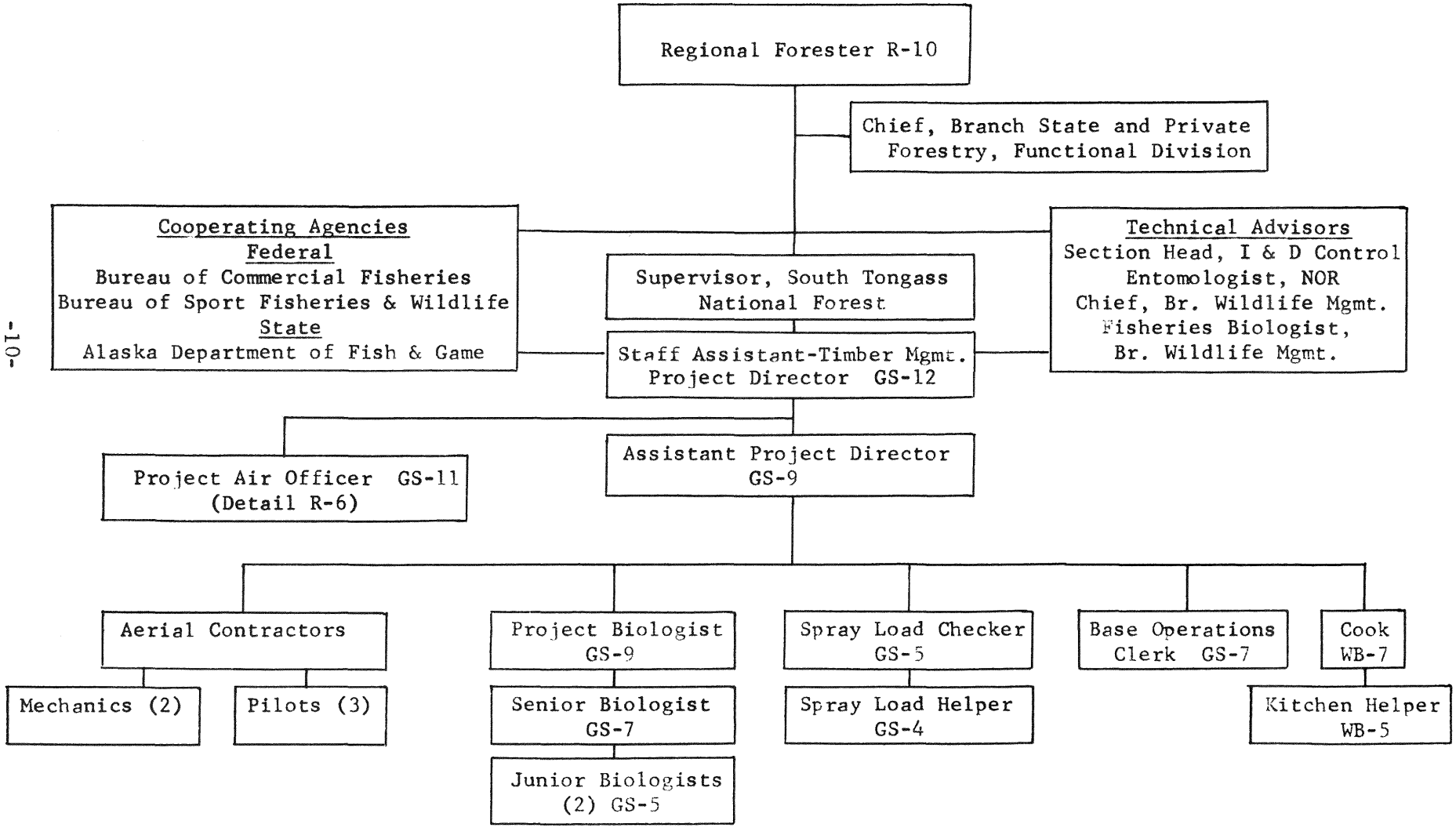


Figure 3. Shown above are the three spray block areas, (No's 1, 2, and 3) and the two control areas that were used for fish studies (No.'s 4 and 5.) These areas are referred to in the text as follows:

No. 1 - Virginia Creek
No. 2 - Cabin Creek
No. 3 - Dog Salmon Creek
No. 4 - Old Tom Creek
No. 5 - Saltery Cove

Fish and water studies were conducted in the Virginia and Cabin Creek blocks, while the wildlife studies were confined to the Cabin Creek block.

Figure 4 - Skowl Arm Project Organization Chart



EXECUTION OF THE PROJECT

It took 14 days, June 4 to June 18, for a crew of five men working under the direction of the Assistant Project Director to set up the airbase. The completed base is pictured in figure 5.

INSTALLATION OF THE LOADING AND METERING EQUIPMENT

The loading and metering equipment was installed in such a way that both the PBY and the helicopter spraying operations could be conducted simultaneously. To insure that a maximum amount of information would be obtained for the time-cost study, it was later decided, however, that the two operations should be carried out separately and that the PBY operation should be completed before the helicopter operation would begin.

The pump and motor assembly was located on the wooden scow at one end of the storage tank and level with the bottom of the tank. A meter and hose reel were mounted on both the PBY float and the helifloat. A 2-inch neoprene hose fitted with a brass foot valve functioned as a suction line between the tank and the pump. From the pump, the insecticide was supplied through a 2-inch neoprene hose to the metering station on the PBY float and through a 1½-inch neoprene hose to the metering station on the helifloat.

This arrangement provided an operational delivery rate of 100 gallons per minute at the PBY loading nozzle and 50 gallons per minute at the helicopter loading nozzle.

MIXING OF THE INSECTICIDE

Since the storage tank was not large enough to mix 10,300 gallons of insecticide, two batches had to be mixed. The first batch of 9,312 gallons, which was more than enough to complete the PBY operation, was mixed immediately after the loading and metering equipment was installed.

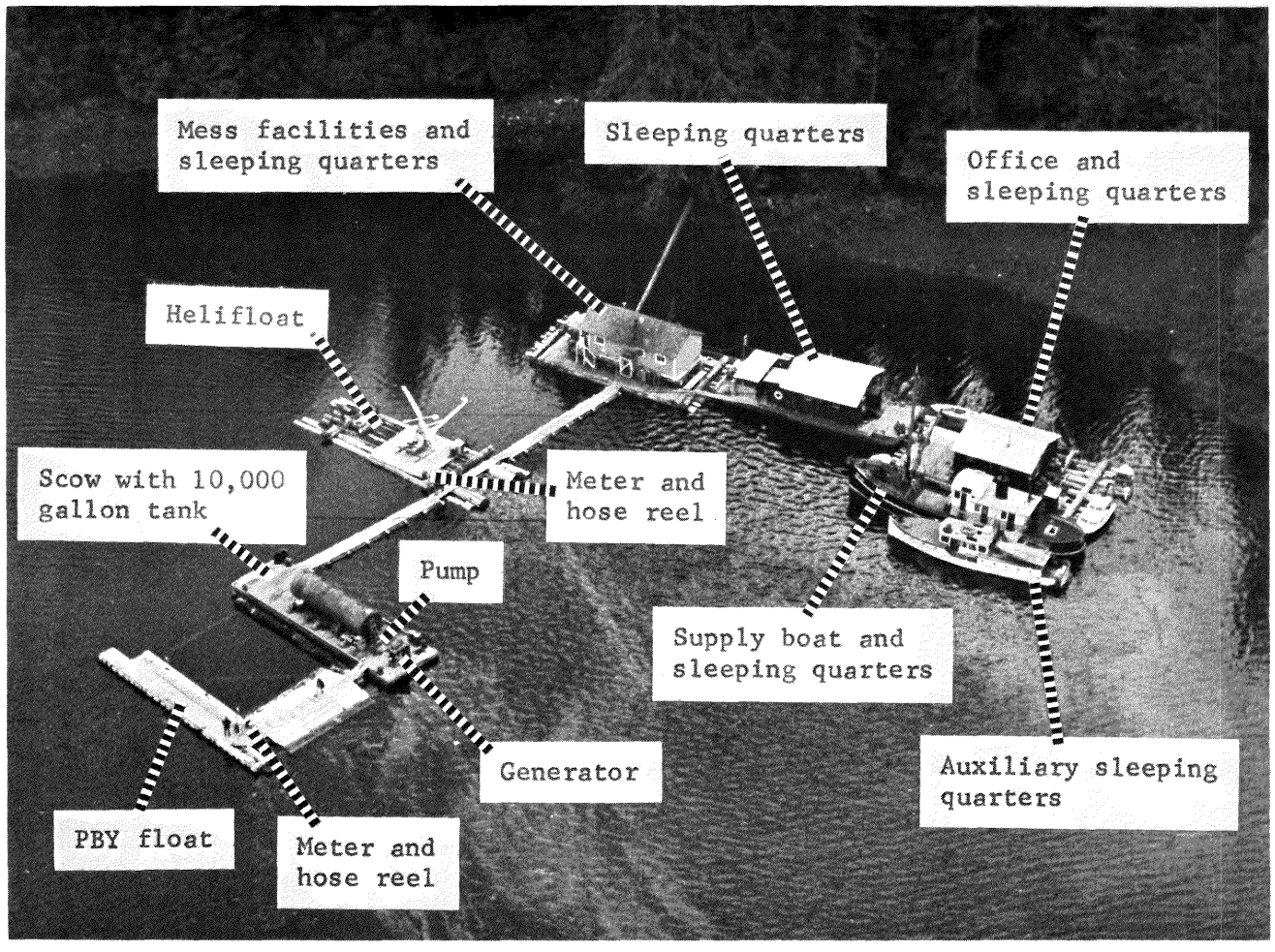


Figure 5. Aerial view of the airbase. Labels denote location and function of the important items which made up the airbase.

In the first mixing, the hose running from the pump to the meter on the helifloat was uncoupled at the meter and connected to the storage tank. The hose was then used as a return line for re-circulating and mixing the insecticide.

When the second batch of 1,164 gallons was mixed, the line from the pump to the meter on the PBY float was used as the return line.

TRAINING AND SAFETY

Safety was stressed throughout all phases of the project. On June 11 and 12, the Safety and Training Officer from the Regional Office was on hand to help the Assistant Project Director in conducting a 6 hour orientation-type session for personnel assigned to the project.

This involved:

1. A discussion of the specific duties and responsibilities of all personnel.

2. Showing of an informational film obtained from the British Columbia Forest Service, entitled "Counter Attack." This film was selected because it pointed up the importance and cooperative nature of such projects in the overall forest management program.

3. Showing of the film "Pulse of Life," in which various techniques of applying artificial respiration were pointed out. This film tied into a discussion of the safety aspects of the floating airbase and small boat handling.

4. A safety check of the entire airbase was made with all members of the project participating. Corrections were made on-the-spot during this "hazard hunt."

Another special session for all project members was held on the evening of June 14. During this session, the Project Air Officer used slides to point out the special safety measures required in aircraft operations.

On June 17, the aerial contractors arrived at the airbase. Two pilot indoctrination sessions were held - one at the airbase, the other in the air.

At the airbase, the contracts were reviewed and the need for safety was stressed. The flight patterns and boundaries of the spray blocks were pinpointed on specially prepared aerial photo mosaics with scales of 4 inches to the mile and on topographic maps with scales of 1 inch to the mile. Copies of the mosaics and maps were issued to the spray pilots for their use in controlling spray runs. These were to be supplemented during the spraying operation by the radio system installed for the project. This system provided a communication link between spray aircraft, the control aircraft, and the airbase.

Emergency conditions sometimes require the dumping of a spray load in spite of attending hazards to fish and wildlife. The pilots were instructed that, if possible, any emergency dumping should be made over the barren ground above timber line. However, in case of extreme danger to the pilots, the spray load would be dumped where necessary to save human life. It was especially important for the pilot of the PBY to know the location of the dump zone since he would be unable to land his aircraft while carrying more than 660 gallons of insecticide. Therefore, if the PBY experienced mechanical difficulties or if the weather conditions changed so that the spraying operation could not continue, the pilot would have to jettison his load before landing.

During the aerial session, the flight patterns and boundaries of the spray blocks were again pointed out. This session also enabled the pilots to become familiar with the terrain and the location of the dump area.

SPRAYING

Spraying was conducted on 5 days in the period June 18 to June 25.

On June 17, two 2-man crews of biologists were flown by helicopter into the Virginia Creek spray block to lay out a single spray card line because it was anticipated that the weather would be satisfactory for spraying on June 18. The work of the biologists in placing and collecting the spray deposit cards is considered part of the spraying activity.

The 4 p.m. report from Annette Island[2/] on June 17, indicated that weather conditions on June 18 might be satisfactory for spraying.

2/ A report from the U. S. Weather Bureau at Annette Island, received at 4 p.m. each day at the project airbase, gave information as to the expected weather for the following day. In addition, weather conditions at the airbase were checked at 2 a.m.

Figure 6. Safety measures included posting of all hazard areas.

First Day of Spraying

A slight rain was falling at the time of the 2 a.m. weather check on June 18. By 10 a.m., however, the weather was clearing, so the PBY was loaded with 1,442 gallons of insecticide and put on standby.

At 1:18 p.m., under somewhat marginal spraying conditions, the PBY flew to the Virginia Creek block to spray this load and returned to the airbase at 2:19 p.m. At that time, weather conditions were growing steadily worse, so the operation was shut down for the remainder of the day.

Meanwhile, the biological crews were laying out two spray card lines in the Cabin Creek spray block.

Second Day of Spraying

Windy, rainy weather prevailed on June 19 and 20 so that no spraying was conducted on either day. The biologists, however, laid out additional cards on and around Cabin Lake and checked on the budworm development in the Dog Salmon spray block that was to be sprayed by helicopter.

The weather check at 2 a.m. on June 21 showed that conditions were right for spraying. The PBY, carrying the first of two 1,442-gallon loads of insecticide to be sprayed in the Virginia Creek block, took off at 3:50 a.m.

After completing the spraying of the Virginia Creek block, the PBY sprayed two loads of 1,439 gallons each on the Cabin Creek block.

The PBY returned to the airbase for the last time at 9:30 a.m., completing the PBY phase of the spraying operation.

Throughout the day of June 21, Forest Service biologists worked with personnel from the Bureau of Commercial Fisheries in collecting samples necessary for the fish studies and also laid out a spray card line on the Dog Salmon spray block.

Third Day of Spraying

Helicopter spraying started at 4 a.m. on June 22. The helicopter sprayed loads varying between 80 and 100 gallons of insecticide depending on how much fuel it was carrying. At 10:45 a.m. high winds forced spraying to be discontinued for the day.

Figure 7. Loading PBY with insecticide.

Figure 8. Loading helicopter with insecticide.

The crews of biologists spent the day picking up the spray cards from the Virginia Creek block and the Cabin Lake area.

Fourth Day of Spraying

High winds and a drizzling rain prevented any spray work on June 23, but the biologists were able to pick up the spray cards from the Dog Salmon block. The weather improved on June 24, so spraying resumed at 6:12 a.m. and continued through the day until 5:25 p.m.

The biologists spent the day collecting the spray cards from the two lines in the Cabin Creek block and laying out two more card lines in the Dog Salmon block.

Fifth Day of Spraying

On June 25, the spray helicopter took off at 8:45 a.m. to begin the last day of spraying. Spraying was completed at 4:10 p.m.

The spray cards were collected from Dog Salmon Creek in late afternoon following completion of the spraying.

AIRCRAFT

The aircraft needed for the project were of two general types, spray planes and planes used for observation and control of spray planes and for ferrying project biologists to and from field positions.

SPRAY AIRCRAFT

In order to satisfy the project objectives, it was necessary that both a PBY and a helicopter be used to do the spraying.

PBY

On March 22, 1963, bids were issued to 22 prospective bidders. The bids called for the contractor to provide the following:

1. One PBY amphibious aircraft equipped to deposit spray according to stipulated requirements.

2. One PBY spray plane available on 48-hour notice.

3. Pilot, co-pilot, and FAA-rated mechanic.

4. Fuel for spray plane.

Only Firefly, Inc., Portland, Oregon, quoting a price of $1.12 per acre for 7,204 acres qualified in the bidding. One other firm returned the bid, but could not qualify.

Before awarding the contract, however, the Project Air Officer made an inspection of the successful bidder's aircraft on May 5, 1963. Final inspection for contract compliance and calibration was made by the Air Officer in Portland, Oregon, on June 8, 1963.

Helicopter

On March 22, 1963, bids were issued to 31 prospective bidders. The only bid returned was from Temsco Helicopters, Inc., Ketchikan, Alaska. This firm's bid was returned with qualifications and was

rejected. A negotiated contract was then reached with the firm, containing the following provisions:

1. The firm was allowed $500 to equip their aircraft with spraying gear.

2. A guarantee of 20 hours flying time at $246 per hour.

3. Temsco agreed to furnish one Hiller 12E helicopter rigged for spraying with a standby helicopter available for use within 48-hour notice.

4. The provisions also called for the firm to provide a qualified helicopter pilot, an FAA-rated mechanic, as well as fuel.

OBSERVATION, CONTROL, AND FERRYING AIRCRAFT

Two fixed-wing ships, a Cessna 185 and a Piper PA12, were used for control and observation, while a Hiller 12E helicopter was used for control and observation and for transporting the project biologists to and from field positions.

Cessna 185

The Cessna 185 was equipped with float gear and dual controls. The plane, with pilot, was furnished by Webber Air, Inc., Ketchikan, Alaska, under an existing GSA contract. The contract rate was $54 per hour for flying time and $20 per hour for standby time.

Piper PA12

The Piper PA12 was equipped with float gear and was furnished, with a pilot, by Temsco Helicopters, Inc., under an existing GSA contract. The contract rate was $28.50 per hour for flying time and $14.25 per hour for standby time.

Hiller 12E

Temsco Helicopters, Inc., furnished the Hiller 12E, with pilot and float gear, under an existing GSA contract. The contract rate was $130 per hour with the guarantee of 3 hours per day.

EQUIPMENT AND FACILITIES

The equipment and facilities that had to be provided for the project fell into four categories: the insecticide storage facilities, the aircraft floats, the pumping and metering equipment, and the office, sleeping, and mess facilities.

INSECTICIDE STORAGE

The insecticide storage facilities consisted of a 10,000 gallon tank rigged on a wooden scow. These were furnished by McKay Transportation Company, Ketchikan, Alaska, under a demise charter arrangement. McKay furnished a tow boat and operator in addition to the tank and scow. The tow boat was used to transport fuel oil, DDT concentrate, aviation gasoline, and other supplies from Ketchikan to the airbase. A rate of $150 per day was charged for the scow with storage tank and $200 per day for the tow boat and operator.

AIRCRAFT FLOATS

Two aircraft floats were needed, one for the PBY, the other for the helicopter.

PBY Float

The PBY float used on this project was a modified version of the float design included in Benton Howard's report of 1960. The pinch float section and the small deck next to the wing pontoon were eliminated, but the float log under the small deck was left in place in order to maintain strength. A bumper rail was extended 8 inches from the outside edge of the float to give more clearance for the wing pontoon. The float was constructed by a logging operator in the Skowl Arm area at a cost of $3,900.

Helifloat

An Equipment Agreement was used to lease a 24- by 65-foot float from a logging operator in the Skowl Arm area. The rental was $150 for the duration of the project.

Figure 9. Tow boat used to transport supplies to airbase. Boat also provided 7 extra bunks.

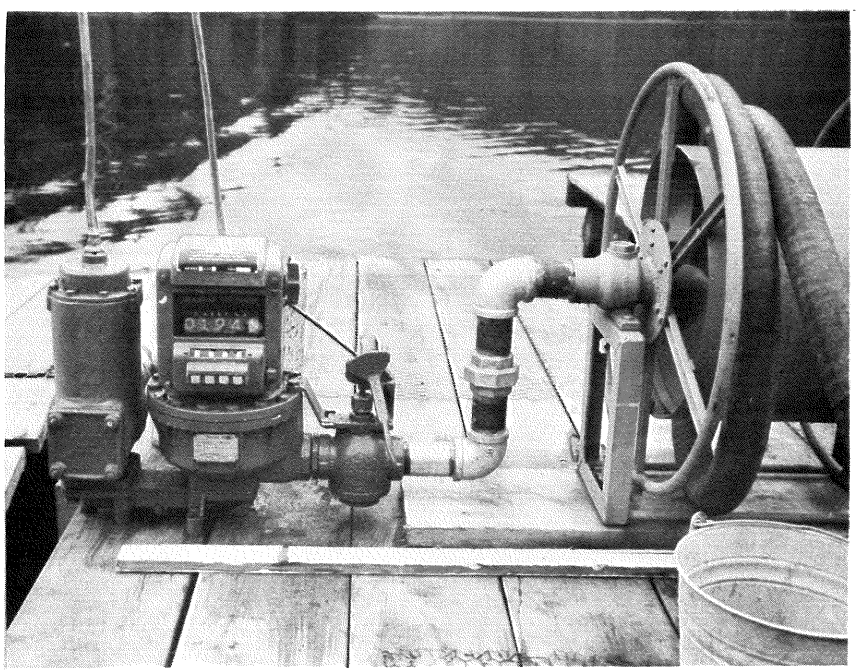


Figure 10. Meter and hose reel. Meter is pre-set to shut off automatically, preventing spillage of insecticide.

A 20- by 20-foot area was decked with 2 inch planking on one end of the float to provide a landing pad.

PUMPING AND METERING EQUIPMENT

The pumping and metering equipment was purchased on the open market for $2,100 in Seattle, Washington, and shipped to Ketchikan on a government bill of lading.

This equipment consisted of:

1. Worthington 1½ CN42 centrifugal pump with a 3 hp 110 V. electric motor.

2. Neptune Red Seal 1½-inch type 4 meter with 400 series register.

3. Neptune Red Seal 2-inch type 4 meter with 400 series register.

4. Suction, supply, and delivery hose 1½-inch and 2-inch with brass fittings and nozzles.

5. 1½-inch hose reel.

6. 2-inch hose reel.

The meters came equipped with predetermined gallonage settings and automatic shutoff valves. Included in the metering units were 80 mesh filter assemblies and air release vents.

OFFICE, SLEEPING, AND MESS FACILITIES

Three Forest Service wanigans and two boats furnished the necessary space and equipment for office, sleeping, and mess facilities.

The office was located on one wanigan and confined to an 8- by 10-foot space normally used as a kitchen. A total of 35 bunks were available for sleeping, 16 on the 3 wanigans and 19 on the two boats. The mess facilities were located on one wanigan. The kitchen was equipped with two gas refrigerators and one gas and one oil range. Maximum seating capacity was 12 people per setting.

AIR COMMUNICATION EQUIPMENT

Radio frequency 3411.5 was used for communications between the spray plane and the chase plane and between the planes and the airbase. The PBY started the project with a VHF radio, but this type of radio does not appear to give adequate performance in southeast Alaska.

The importance of good radio communication between the airbase and the spray planes was pointed up when failure of the VHF radio made it impossible to recall the PBY with its first load of insecticide after air conditions became unsuitable for spraying. This caused some drifting of spray beyond the target area. Satisfactory communication was maintained after the installation of the 3411.5 radio frequency.

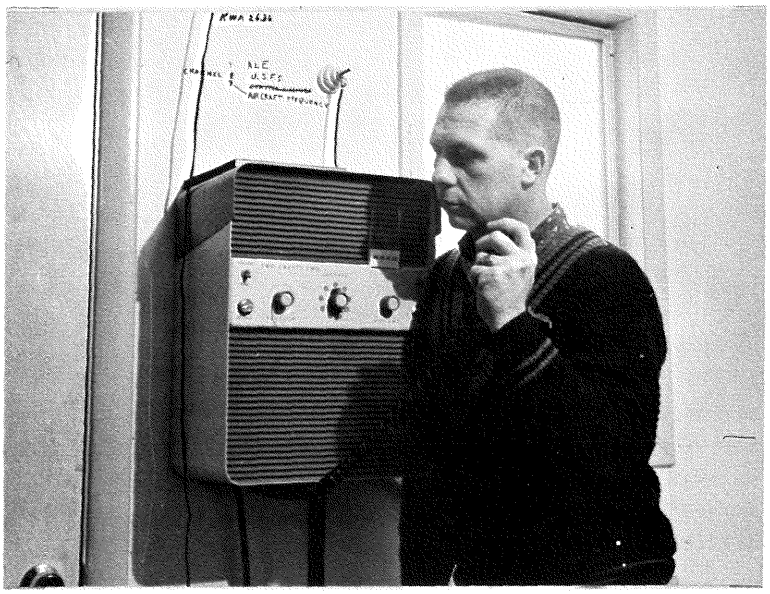


Figure 11. Airbase radio used to contact planes, and points outside spray area.

SPRAY MATERIALS

The DDT concentrate was purchased on the open market after quotations were received and evaluated from three chemical companies. Great Western Chemical Company batched 900 gallons of concentrate at their St. Louis, Missouri, plant. They furnished the concentrate F.O.B. Ketchikan for $1.69 per gallon.

Region 9, U. S. Forest Service, provided a man to collect DDT samples at the manufacturing plant. The samples were then sent to the Agriculture Research Laboratory in Yakima, Washington, for analysis. Results of the analysis showed that the concentrate was batched at the rate of 2.91 pounds of DDT per gallon of solvent rather than the 3.5 pounds per gallon as specified. Because of the time factor, the concentrate was accepted and the mixing formula revised accordingly.

The DDT concentrate was mixed by the Forest Service with 9,576 gallons of fuel oil to produce 10,476 gallons of insecticide. Fuel oil was purchased under an existing GSA contract for $0.1539 per gallon.

RESULTS AND DISCUSSION

The Skowl Arm DDT Pilot Project showed it is possible to conduct a water-based aerial spraying operation in southeast Alaska. With some exceptions, the equipment used performed satisfactorily. The costs involved were higher than what they would be on any future aerial pest control project because of the developmental nature of the Skowl Arm Project.

EVALUATION OF AIRCRAFT

PBY

The PBY, with two engines rated at 1700 horsepower, required a run of one mile for take-off from the water when carrying its normal load of 1,440 gallons of insecticide. A straight-away course of two miles should be available with adequate provision for gaining the necessary spraying altitude of 400 feet above the terrain. This craft sprayed an average rate of 1,814 acres per hour. The spray cards indicated that fair coverage was obtained. Because of the wind and tide conditions, the pilot had difficulty docking the PBY. This could be remedied somewhat by improving the design of the float. A more thorough discussion is presented in the section dealing with the evaluation of the PBY float.

Helicopter

The Hiller 12E had adequate power to spray with 80 to 100 gallons of insecticide per load. No difficulties were experienced either in landing or taking off from the float base. Although the pilots were inexperienced in forest spraying, spray coverage on the spray cards was satisfactory.

Cessna 185

The float-equipped Cessna 185, used to observe the PBY spray plane in operation, did not have an adequate margin of speed over that of the PBY to enable it to perform as a chase plane for the entire length of a spray run. A faster plane would have been desirable, but this would mean using a costly two-engine amphibian aircraft, since a faster single-engine plane on floats is not available.

Observation was obtained from the Cessna 185 by positioning the plane in the center of the spray block, well above the PBY. In such a position, the Project Air Officer could observe the greater portion of the spray plane's work, but his control of the PBY on the beginning and end of each run was inadequate.

For aerial control on future spray work, it might be well to investigate the possibility of using the "flag plane" technique that has recently been developed by the Canadians in their work in New Brunswick.

Piper PA12

Aerial observation of the spray helicopter in operation started using a Piper PA12, but was discontinued when it became apparent that the speed of the Piper was too great for the spraying helicopter. The extra 12E helicopter was then used and proved entirely satisfactory. Adequate observation could be obtained with a lighter helicopter at a lower per hour rental charge.

EVALUATION OF FLOATS

PBY-Float

The PBY float was adequate for operational functions after the plane had been secured; and the location of the meter and hose reel was satisfactory. However, the interaction of tide and breeze made it difficult for the pilot of the rudderless amphibian to contact the float. A larger target must be allowed to make it easier for the pilot to contact the float, and a larger platform should be provided to allow men to move about freely when bringing the plane into mooring position. The float should possibly by made twice as long as the plane and at least half as wide as the wing span to correct the above deficiencies.

Helicopter Float

The 24-foot width of the helifloat and the decked landing area of 20 by 20 feet was not adequate. The width of the float did not provide enough clearance for personnel to efficiently and safely service and work around the helicopter. Maintenance personnel had to crawl under the tail boom and across the skids when work required them to move to the other side of the aircraft. A decked area of possibly 20 by 40 feet, however, should provide the necessary working space for maintenance personnel and would enable them to service the entire length of the ship.

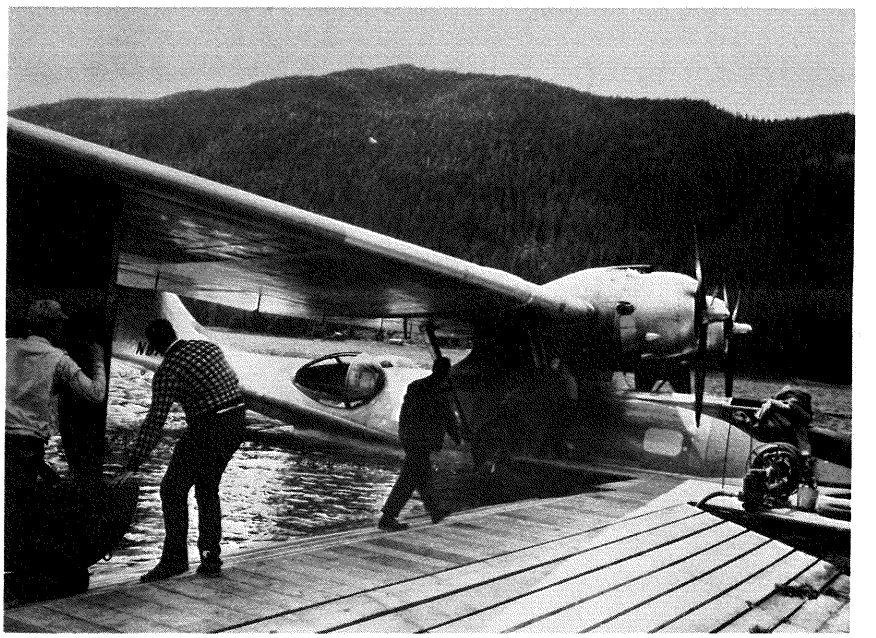


Figure 12. Docking PBY for insecticide loading operation.

Figure 13. Helicopter landing on float.

Facilities for parking the observation helicopter were inadequate. The decked area on the PBY float was used, but it was too narrow for the pilot to land the helicopter with ease and for personnel to enter or depart from the helicopter safely. One solution to this problem would be to provide a single landing pad large enough to accommodate two or more helicopters. Using this arrangement, the rotor tips of adjacent helicopters would have to be separated by isolation strips of at least 15 feet in order to provide a good safety margin. Another possible solution would be to have individual landing pads for each helicopter. These could be well separated and skiffs used for transportation to and from them, rather than using a system of catwalks.

EVALUATION OF THE INSECTIDICE STORAGE FACILITIES

The 10,000 gallon tank rigged on the wooden scow, used to store the insecticide, worked out very well. It would be desirable to have such a set-up on a mobile helicopter operation. For a large fixed-wing operation, however, additional storage tanks would be needed.

EVALUATION OF THE PUMPING AND METERING EQUIPMENT

The pumping and metering equipment used on this project gave exceptionally good service, A possible improvement would be the addition of a special filtering unit between the insecticide pump and the suction hose.

EVALUATION OF THE OFFICE, SLEEPING, AND MESS FACILITIES

The 8- by 10-foot office area was inadequate. At least a 10- by 12-foot office area is needed, and this area should be segregated from other project activities.

The mess and sleeping facilities of 24-person capacity proved to be adequate. It would be desirable, however, to have the kitchen and serving areas in adjoining rooms, rather than in the same room as they were on this project.

Unused space on a floating camp is limited; however, a specific "smoking" area should be set aside where men on off-duty hours can congregate and not disrupt the normal flow of activity or worry about the hazards connected with the air operations.

COMPARISON OF PBY AND HELICOPTER

As was to be expected, the PBY sprayed many more acres per hour at a lower cost per acre than the helicopter, but the helicopter showed superior coverage on the spray cards. This is not surprising, as the helicopter sprayed at a height of 30 to 40 feet above tree tops at speeds of 45 to 50 miles per hour[3/] while the PBY flew at heights of 200 to 400 feet above the trees at a speed of 120 miles per hour. The application costs on this project were $1.12 per acre for the PBY and $2.05 per acre for the helicopter.

One helicopter operator in the Juneau area offered to spray the entire 10,000 acres for a flat rate of $1 per acre, and on such terms the cost per acre to spray 10,000 to 12,000 acres would be the same for either the PBY or the helicopter. For normal control projects of 100,000 acres or more, however, the PBY would doubtless spray at a lower unit rate than the helicopter.

The weakness of the helicopter for large scale spraying in southeast Alaska is more one of availability than one of cost per acre. On the Skowl Arm Project, the PBY sprayed 1,814 acres per hour and the helicopter 130 acres. Even when assuming that the helicopter could spray 6 hours a day while the PBY sprayed 4 hours a day, the PBY could still spray 8 to 9 times more acres per day or season than the helicopter. It is unlikely that for a 100,000 acre project sufficient helicopters and facilities for servicing them would be available.

3/ Moving pictures of a helicopter spraying at 30 m.p.h. ("Operation Whip" - hemlock looper control in Washington) showed pronounced rotor effect driving the spray downward. However, still slides taken of the Skowl Arm helicopter flying at 45 - 50 m.p.h. showed little of this rotor effect.

—·—·— Actual Cost: Helicopter: Skowl Arm Project

····· Costs as given by Temsco Helicopters Inc. These costs may be used as a planning guide.

——— Actual cost PBY - Skowl Arm Project (As qualified in the contract).

– – – – – – Projected cost PBY

The higher cost involved in setting up a PBY operation enables the helicopter to compete on a total cost per acre basis for an operation up to 12,000 acres.

Figure 14. Comparison of Project Spraying Costs - PBY and Helicopter.

PROJECTS COSTS

The total cost of the 10,300 acre pilot project was $72,419.75 or $7.03 per acre. A breakdown of the project costs follows:

Aerial Spraying			
PBY		$ 8,068.48	
Helicopter		6,354.80	
	Total	14,423.28	$14,423.28
Aerial Observation			
Cessna 185		243.00	
Piper PA12 & Hiller 12E		1,215.00	
	Total	1,458.00	1,458.00
Insecticide			
DDT concentrate		1,521.00	
Fuel oil		1,473.75	
	Total	2,994.75	2,994.75
Storage Facilities		9,450.00	9,450.00
Pumping and Metering Equipment		2,100.00	2,100.00
Floats			
PBY		3,900.00	
Helicopter		150.00	
	Total	4,050.00	4,050.00
Salaries, Personnel Transportation, Supplies, Food, Towage for Assembling Equipment, Freight and Miscellaneous		37,943.72	37,943.72
	TOTAL		$72,419.75

The very nature of a pilot project dictates that certain expenditures will be necessarily greater than what would be expected under standard operating conditions. This being the case, on any future spray projects, because of the experience gained here, the costs of planning, travel, and supervision would be reduced considerably, so that the expected cost could range from $3.50 to $4 per acre.

By handling an entire operation on a contract basis, it should be possible to reduce the cost per acre even more. Assuming the contractor charged $1 per acre for application and $1 to $2 per acre for supplying materials, the cost might be reduced to as low as $2 to $3 per acre.

BIOLOGICAL PHASES

The responsibilities of the biologists on the Skowl Arm Project were three-fold:

1. Release blocks for spraying at the proper stage of insect development.

2. Determine degree of insect control obtained with 1/4 pound of DDT per acre.

3. Determine adequacy of spray coverage by use of spray deposit cards.

BIOLOGY OF THE BLACK-HEADED BUDWORM

The primary host of the black-headed budworm in southeast Alaska is the western hemlock, with mountain hemlock and Sitka spruce also attacked.

The black-headed budworm spends the winter as a small yellow flattened egg laid singly on the underside of hemlock needles. The eggs commence hatching when the hemlock buds start opening in late May or June. The small green larvae with black heads feed on the opening buds, webbing the needles together to form a protective case. The larvae grow to a length of about 1/2 inch and pass through five stages or instars, the last one of which has a brown head.

In late July or August, the larvae change to the pupal stage, remaining on the branches, and emerging as moths in a period of two to three weeks.

The moths are gray dappled with brown, black, orange or white, with a wing expanse up to 3/4 inches, and emerge in August and September. After a brief period they commence laying eggs, in which stage the insect spends the winter. The moths concentrate on the upper third of the tree crown, but some eggs are laid on exposed branches near the ground.

The hemlock sawfly has not been considered in the biological phases of the project. It is assumed that the findings of the project would apply to hemlock sawfly control as well as to the black-headed budworm.

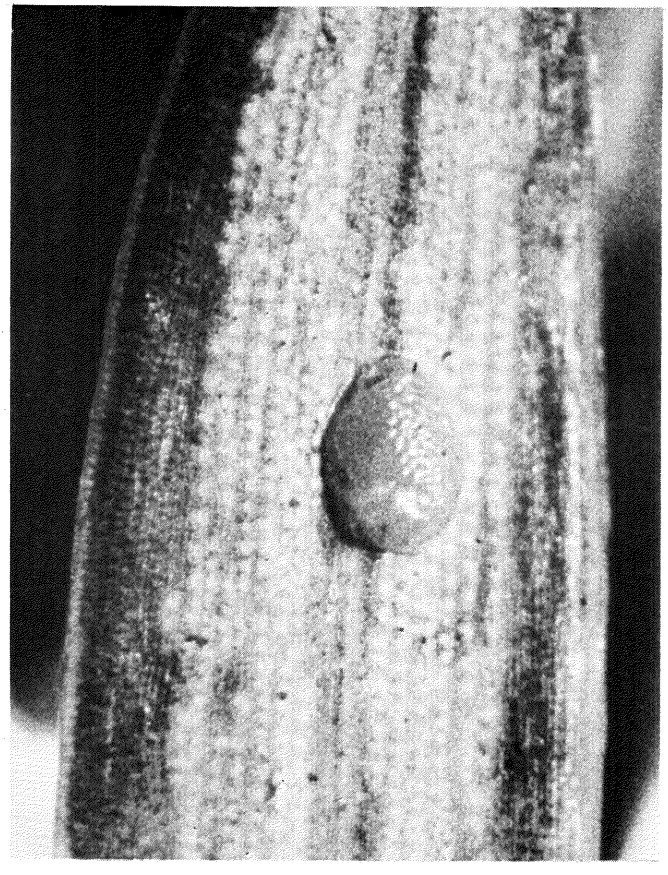


Figure 15. Egg of black-headed budworm on underside of hemlock needle. 40 x

Figure 16. Black-headed budworm feeding on new needles. 10 x

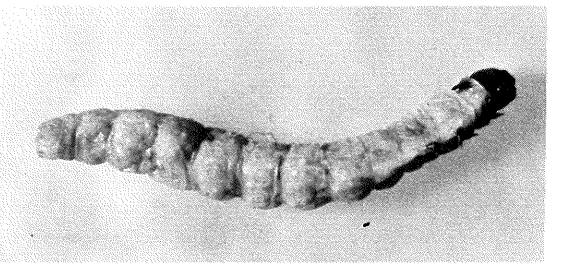


Figure 17. Fifth instar larva of black-headed budworm. 5 x.

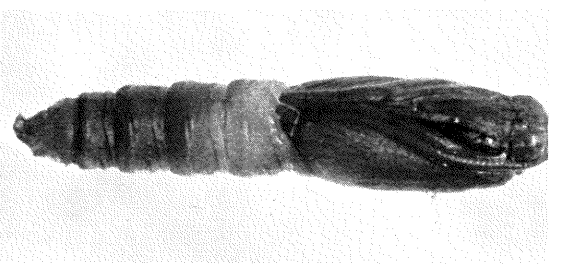


Figure 18. Cocoon of black-headed budworm. 5 x.

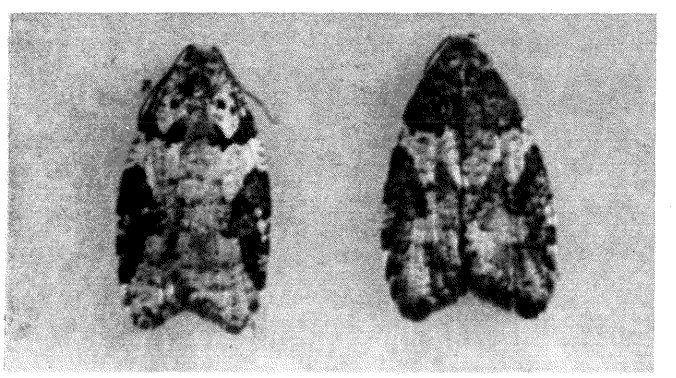


Figure 19. Moths of black-headed budworm. 2 x. Notice variable markings.

PRE-SPRAY BUDWORM POPULATION

Epidemic insect populations normally supply all the insects needed for developmental studies or assessments of insect mortality resulting from insecticide treatments. When the pilot project was first conceived in 1960, a moderate budworm population was present in the area and an increase in numbers seemed probable. It was recognized that the infestation could decrease or increase, but the pre- and post-spray requirements of the fish study dictated the confinement of the studies to the same area for a period of 3 to 5 years. Surveys of the overwintering stage of the budworm in the fall of 1962 and spring of 1963 showed drastic decreases in budworm populations at Skowl Arm and the surrounding 25 miles; consequently, in June 1963, while all the requirements of fish, wildlife and operational phases of the project had been satisfied, the biological phases were not ready because of a lack of adequate budworm population with which to work.

Forest entomologists are now convinced that light insect populations are not satisfactory for evaluating the effectiveness of insect control measures. It was decided by the technical advisers that a medium population of budworms would be necessary for valid assessments of the effects of 1/4 pound of DDT on the budworm. The prediction of budworm populations expected in the coming season is based on the relative abundance of the overwintering egg stage. Egg counts for the Skowl Arm Project were made on 10-inch branch samples taken from the upper third of felled trees and the results recorded as the number of budworm eggs per 100 linear inches of hemlock foliage. Using the guidelines set by Silver and Lejuene,[4/] a medium population of 30 eggs per 100 inches of foliage was specified for studies on this project.

The relationship established by these two workers between overwintering egg population and resulting defoliation and damage is summarized below.

No. Eggs Per 100 Linear Inches	Degree of Defoliation and Effects
1-10	Light - up to 25% defoliation of current growth.
11-29	Medium - bare tips, some tops heavily defoliated.

4/ Silver, G. T. and Legeune, R. R. Report on the Black-headed Budworm Infestation - North Vancouver Island, 1955.

No. Eggs Per 100 Linear Inches	Degree of Defoliation and Effects
30-99	Heavy - trees red in appearance, tips bare, tops heavily defoliated.
100+	Very heavy - numerous tree tops completely defoliated. Top kill common.

An intensive search was made within a 25 mile radius of Skowl Arm to find budworm populations adequate for test purposes. Starting in late April of 1963, groups of 2-8 trees were felled and egg counts obtained. A summary of the egg counts on 51 trees from 14 locations follows:

Location	No. Trees	Eggs Per 100 Linear Inches
Cabin Creek	6	.30
Old Tom Creek	2	.15
Dog Salmon	8	.35
Thorne River #1	3	.47
Thorne River #2	4	13.92
Thorne River #3	3	1.61
Thorne River #4	2	11.90
Tolstoi Bay	6	4.20
Crab Creek - Craig	3	8.73
Coronado Is. #1	2	4.47
Coronado Is. #2	3	2.37
Coronado Is. #3	2	9.18
St. Nicholas Bay #1	4	3.20
St. Nicholas Bay #2	3	15.69

Since none of the egg counts obtained approached the required standard of 30 eggs per 100 linear inches, it was decided to cancel the planned insect mortality studies on the spray areas.

EXPERIMENT TO OBTAIN BUDWORMS FOR TEST PURPOSES

A new plan was devised for the insect mortality study when it became obvious that budworm populations in the Skowl Arm area were inadequate for scientific studies. In this alternate plan, budworm eggs would be gathered from newly felled trees, retaining 1-1½ inches of twig with each egg, and these twigs would be attached to the lower branches of study trees on the area to be sprayed by the helicopter and on one of the fish study check plots. A total of 694 eggs were collected and planted in 6 plots, 3 on Dog Salmon Creek and 3 on the fish study block, Old Tom Creek. All sample twigs were

collected 2-3 days after spraying and examined in the laboratory to determine the success of this transplanting technique. Normally, a lapse of 7-10 days would be permitted for the DDT to have full effect, but little effect could be expected upon budworm eggs and early instar larvae, the only budworm stages present owing to the adverse climatic conditions.

The results of the transplanted budworm egg experiment are summarized below:

	Old Tom Control		Dog Salmon Spray Area	
	Number	Percent	Number	Percent
Live Larvae	18	6.3	26	6.3
Dead Larvae	10	3.5	14	3.4
Egg Membrane	70	24.7	109	26.5
Black Eggs*	15	5.3	14	3.4
Normal Eggs	10	3.5	16	3.8
No Recovery	160	56.5	232	56.4
TOTALS	283	99.8	411	99.8

*Parasitized, no emergence expected.

It is apparent that this technique of transplanting budworm eggs needs further refinement before it can be of any practical value, since over 50% of the insects were lost outright and less than 10% of the original population was available when final examinations were made.

INFLUENCE OF LATE SEASON ON BUDWORM DEVELOPMENT

A later than normal spring retarded the development of the budworm in the Skowl Arm area. According to the original plan, blocks were to be released for spraying when 60% of the larvae had reached the third stage, or instar; and, under average conditions, this would have occurred about June 15. However, the Skowl Arm area experienced a cold, wet spring, and by mid-June budworm development was at least two weeks behind that at Limestone Inlet, over 150 miles northward where the Northern Forest Experiment Station is maintaining a field laboratory. Hence in the third and fourth weeks of June a fair proportion of the budworm eggs had not hatched, and no more than 20% of the budworm population had reached the third instar.

RELEASE OF BLOCKS FOR SPRAYING

In normal spraying practice, blocks of woodland are released for spraying when insect development on a block has reached a predetermined stage. However, on the Skowl Arm Project, it was determined that budworm populations were too light for test purposes and that insect development was retarded approximately two weeks by a cold, wet spring. In view of these circumstances, it was decided to commence spraying as soon as the planes could be made ready. The starting signal was given to the PBY on June 17 and the helicopter was permitted to start spraying the moment the PBY had completed its assignment. A decision had been made to complete the PBY spraying before starting with the helicopter in order to simplify servicing the spray craft and recording operational data.

INSECT MORTALITY STUDY

It has been pointed out in preceding sections that black-headed budworm populations were inadequate for valid scientific studies, that efforts to establish experimental budworm populations in the Skowl Arm area were unsuccessful, and that adverse weather conditions had markedly retarded the development of the budworm. It was hoped that in spite of the above adversities the helicopter spraying of the introduced budworms on Dog Salmon Creek would yield some leads on the effectiveness of 1/4 pound of DDT per acre in controlling the budworm.

However, efforts to determine insect mortality from DDT were abandoned completely when it became evident that too long a wait would be involved if the spraying of the test insects on Dog Salmon Creek were to be postponed until 60 percent of the budworms had reached the third instar. This would have meant holding the helicopter and insecticide storage facilities over for 14 days with resultant increased costs. Since it seemed highly doubtful that the transplanted budworm populations could yield any valid data, it was decided to proceed immediately with the helicopter spraying and close the airbase before excessive additional expenditures were incurred.

SPRAY DISTRIBUTION

Satisfactory control of forest insects by aerial spraying depends in large measure upon the even distribution of low volumes of spray (generally one gallon per acre) over carefully demarcated blocks of forest land. The most practical method for determining the type

of spray coverage obtained has been the placement of oil-sensitive cards in and near areas to be sprayed. The use of oil-sensitive cards is explained in a paper by T. M. Davis.[5/]

Spray cards were placed at five chain intervals on lines at right angle to the spray plane's line of flight. See figure 3 for location of the spray card lines. The cards were mounted in wire holders using the technique developed by Maksymiuk.[6/] Six card lines were set out, 1 in Virginia Creek (Block 1), 2 in Cabin Creek (Block 2), and 3 in Dog Salmon Creek (Block 3). In addition, 9 cards were fixed to wooden blocks and floated in 3 lines across the lake in Cabin Creek.

Spray cards were retrieved the day of spraying or by the next day at the latest. Even with prompt recovery of the spray cards, rainfall on the cards made the estimating of deposits on the cards difficult. Spray deposit determinations were made by three biologists, using the standards given in Davis' paper, and average figures were obtained.

A summary of data for the 6 spray card lines follows:

	HELICOPTER	PBY	
	Dog Salmon Creek	Virginia Creek	Cabin Creek
No. Lines	3	1	2
No. Spray Cards	37	25	34
Minimum Deposit*	0.07	0.00	0.00
Maximum Deposit	2.90	0.51	1.30
Average Deposit	1.16	0.15	0.24

*Deposit data is for estimated gallons of oil per acre.

Examination of the spray cards from the lake at Cabin Creek showed an average deposit of 0.09 gallons of spray per acre, with a range of 0.03 to 0.24 gallons per acre. Apparently, the PBY was unable to spray near the lake without permitting some spray to land on the

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5/ Davis, J. M. Standards for Estimating Airplane Spray Deposits on Oil-Sensitive Cards. Forest Service, U. S. Department of Agriculture, Washington, D. C., 1954.

6/ Maksymiuk, B. Improved Holders for Spray Deposit Cards. Jour. Ec. Ent. 52 (5) 1029-30. October 1959.

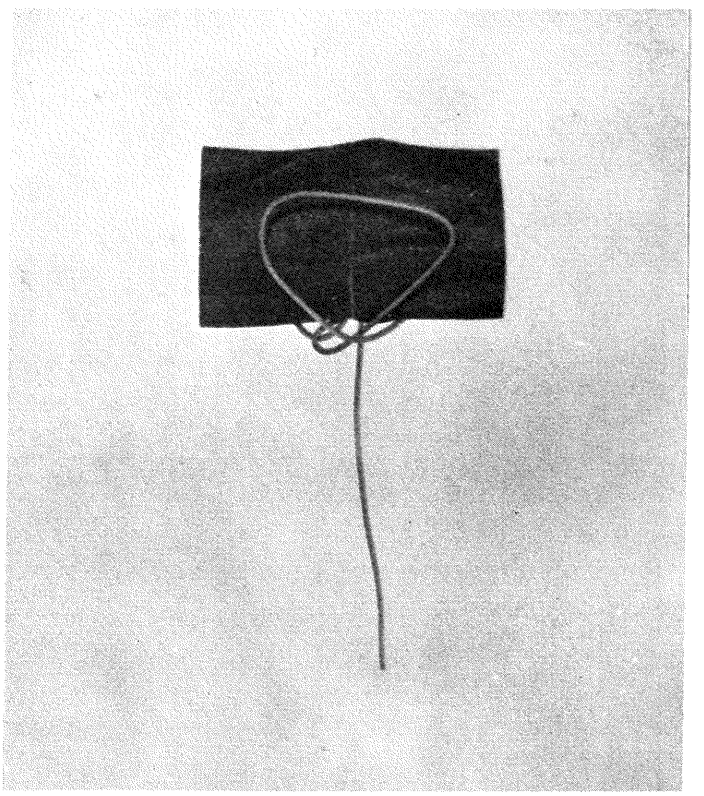

Figure 20. Oil-sensitive dyed spray card (4" x 5") in wire holder. Card surface is horizontal.

water. The box canyon nature of the Cabin Creek drainage may have made it difficult to control spray patterns, and this may have caused spray to land on the lake surface.

The performance of the helicopter was clearly superior to that of the PBY, although lack of experience proved a handicap to the helicopter pilot. The average deposits of 0.15 and 0.24 gallons per acre for the PBY does not compare well with the helicopter deposit of 1.16 gallons per acre. Obviously, the helicopter flying at a height of 30-40 feet above tree tops was able to obtain better coverage than the PBY flying at 200-400 feet.

RECOMMENDATIONS

The following list of recommendations is presented to aid the planning and execution of any future aerial spraying in southeast Alaska.

1. Cooperating agencies should be contacted and special needs as to time and methods for studies by these agencies should be included in the information for contract negotiations.

2. Contractor should have equipment at the date bid is returned to the Contracting Officer.

3. Contract procurement should be used for observation aircraft (fixed-wing and helicopter) to obtain lowest hourly rate and eliminate the daily guarantee under existing GSA contract.

4. Helicopter contracts should state that shoulder harness is not to be connected to engine assembly.

5. Contract should definitely state that calibration costs are borne by the contractor.

6. Project Director and Air Officer should select airbase site together, and this should be at time of minus tide to check for uncharted rocks.

7. Project Air Officer should have plane issued to him and it should be Cessna 185 or equivalent.

8. A qualified helicopter pilot should assist in laying out blocks for helicopter spraying.

9. A helicopter should be used for chase and observation in helicopter spraying.

10. Careful consideration should be given to using existing seaplane ramps and facilities in southeast Alaska for future fixed-wing operations to reduce costs.

11. Regular Weather Bureau forecasts should be supplemented by data from a portable weather station. The portable station should be in radio contact with the airbase, manned at all times, and shifted about as the spraying progresses from one block to another.

12. A maintenance man should be present on the project from start to finish to handle all plumbing, electrical, and carpenter work.

13. A full-time project clerk, well trained in Forest Service business procedures, should be assigned to the project when it is approved and stay on the job until it is completed.

14. Project photographer should have assistant if movie coverage is desired.

15. Office space for the clerk and the biologists should be provided apart from living quarters, and this space should be restricted to official use only.

16. Helicopter facilities should be removed as far as possible from other base facilities.

17. On a large project, the PBY float should be capable of loading more than one PBY.

18. All aircraft should have suitable radios able to perform at U. S. Forest Service AM or FM frequencies.

19. Forest Service should furnish all large fire extinguishers for floating airbase.

20. A gasoline powered pump should be used for mixing the insecticide.

21. A special filter unit should be installed between the insecticide pump and the suction hose.

22. Studies should be conducted to determine the rate of foliage drying after rain and the effect of wet foliage on spray run-off and excessive stream pollution.